COMPARATIVE EFFECT OF PHYSIO-YOGIC, PELVIC FLOOR EXERCISES AND YOGA ON MUSCLE ACTIVATION, CIRCADIAN RHYTHM AND GUT HEALTH AMONG WOMEN WITH FUNCTIONAL CONSTIPATION

SHORT SYNOPSIS

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ABSTRACT

Introduction & Background: Functional Constipation (FC) is a primary type of chronic constipation; it is a functional bowel disorder or disorder of the gut-brain interaction of multi-factorial pathophysiology. FC is particularly prevalent in women, characterised by infrequent, difficult, or incomplete defecation without irritable bowel syndrome. The aetiology of FC is multifactorial, involving physiological, behavioural, and psychological factors. Key risk factors include age, body mass index, socio-economic status, and physical activity.

Abdominopelvic dyssynergia, the impaired relaxation of pelvic floor muscles during defecation, is frequently observed in female patients, complicating symptom management. Behavioural patterns such as delaying defecation or improper toileting postures (e.g., hovering over public toilets) can further exacerbate symptoms and promote chronicity. Effective management of FC requires comprehensive clinical strategies that address both motor coordination and maladaptive behaviours. In contrast, the GI system operates under a circadian rhythm influenced by both central and peripheral factors. Despite this, evidence shows constipation correlates with circadian-dependent alterations in colonic transit after waking or eating and with altered bowel movement frequency versus nonconsolidated individuals. Therefore, this study aims to evaluate and compare the effectiveness of physio-yogic exercises, pelvic floor exercises and yoga on muscle activation, circadian rhythm and gut health among women with functional constipation.

Methodology: This experimental study will recruit women diagnosed with FC based on the Rome criteria. Participants will be allocated into 4 groups: 3 experimental and 1 control group, according to specific inclusion and exclusion criteria. Each group will undergo an 8-week intervention protocol. Outcome measures will be assessed at baseline, then at the 4th week, 8th week, and after a 2-month follow-up. Primary outcome measures will be analysed for the muscle activation, circadian rhythm and gut health, while secondary outcome measures will be examined for additional relevant factors.

Keywords: Functional Constipation; Gut Motility; Physiotherapy; Pelvic Floor; Yoga; Exercise; Circadian Rhythm; Physio-Yogic

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Certificate

I hereby declare that the short synopsis Title "**Comparative Effect of Physio-Yogic, Pelvic Floor Exercises and Yoga on Muscle Activation, Circadian Rhythm and Gut Health Among Women with Functional Constipation**" being submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy in Department of Physiotherapy under School of Allied Health Sciences of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2024-2025. It is a bona fide record of original work carried out under the supervision of **Dr. Jasmine Kaur Chawla** and has not been submitted in full or part to any other university or institute for a degree or diploma. Further, it is certified that the short synopsis is plagiarism-free, and proof has been submitted.

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1. Introduction

1.1 Gut Health

The concept of "gut health" has gained prominence in the scientific literature, particularly as Asian medicine emphasises its significance, viewing the abdomen as central to the location of the soul (Cummings, J. H., et al., 2004; Bischoff, S. C., 2011). Japanese terms like “Onaka” and “Hara” highlight the cultural significance attributed to the intestines (Yu, F. et al., 2006). While Western medicine traditionally regards the intestine as primarily a digestive organ, there is a growing recognition of its broader health implications (Bischoff S. C. 2011). Gut health encompasses both upper and lower gastrointestinal tracts, although discussions often focus on the latter (Bischoff S. C. 2011). The importance of maintaining gut health is underscored by the prevalence of intestinal complaints that drive individuals to seek attention (Bischoff S. C. 2011). Common symptoms include functional dyspepsia and irritable bowel syndrome (IBS), with manifestations such as bloating, flatulence, gastroesophageal reflux, heartburn, nausea, emesis, constipation, diarrhea, food hypersensitivity, urinary incontinence, abdominal discomfort, cramping, and decreased appetite (Bischoff S. C. 2011).

According to the World Health Organisation (WHO), gut health refers to a condition of physical and mental well-being in which individuals do not experience gastrointestinal (GI) issues that necessitate medical attention, exhibit no signs or risks of bowel disease, and are free from any diagnosed bowel disorders. Key features of gut health include the absence of gastrointestinal symptoms such as abdominal pain, diarrhoea, as well as the absence of diseases like inflammatory bowel disease and colon cancer (Staudacher, H. M., & Loughman, A., 2021). It is also influenced by local factors, including normal intestinal permeability, a balanced mucosal state, and appropriate levels of short-chain fatty acids (Staudacher, H. M., & Loughman, A., 2021). Constipation is recognised as the most prevalent gastrointestinal issue among the general public, with increased prevalence noted particularly among women, children, and older adults (Arbizu, R., & Nurko, S., 2016). Constipation can be classified as acute or chronic; chronic constipation typically lasts longer than three months (Gray J. R. 2011; Wald, A., Talley N.J., & Hussain Z. 2024). It may be further categorised as idiopathic/functional (primary) or secondary, arising from various medical or metabolic disorders (Bharucha, A. E., Pemberton, J. H., & Locke, G. R., 2013; Forootan, M., Bagheri, N., & Darvishi, M., 2018). Idiopathic/Functional constipation is mainly categorised into three subtypes: normal transit, slow transit, and pelvic floor dysfunction (Eoff J. C. 2008). In severe cases, an individual may experience <1 BM per week (Ginsberg, D. A., et al., 2007).

1.2 Constipation & Women Health

Constipation is a prevalent condition characterised by difficulty in expelling stool. This may manifest as BMs being excessively hard, inadequately sized, or challenging to pass. Constipation is a common digestive complaint in the general population; it is a symptom-based disorder without standardised diagnostic criteria (Wald, A. 2025). This is generally ignored by the general population because of the

lack of awareness, but it has long-term complications which significantly associated with reduced quality of life and substantial economic burden (Wald, A. 2025). Symptoms may include hard stools, excessive straining, infrequent bowel movement, a sense of inadequate bowel clearance or the necessity to employ manual manoeuvres to assist defecation. “

Functional Constipation (FC) is a primary type of chronic constipation, characterised as a functional bowel disorder or a disorder of the gut-brain interaction with a multi-factorial pathophysiology. FC is defined as a bowel symptom observed without an organic cause. The patient presents challenging, infrequent, or incomplete BMs without fulfilling the diagnostic criteria for IBS (Bouras, E. P., 2010; Longstreth GF et al., 2006). FC does not reveal any discernible biomechanical or structural abnormalities to explain the alterations in bowel patterns (Drossman D. A., 2006), instead, it suggests a dysfunction in the interactive physiology of the related anatomical structures (van Tilburg, M. A. et al., 2008). Experts have worked to establish symptom-based diagnostic criteria for functional constipation, i.e, Rome Criteria III & IV (Pannemans, J., et al., 2020; Bouras, E. P., 2010; Longstreth GF et al., 2006).

Utilising the Rome IV diagnostic questionnaire, a recent three-country population-based survey found that the prevalence of chronic constipation is approximately 9%. Of this, approximately 6% is due to functional constipation (Palsson OS et al. 2016). Overall, FC has a high prevalence of 45% worldwide in adults (Palsson OS et al. 2016). FC, as classified by the Rome Foundation, establishes criteria for diagnosing chronic constipation in the absence of physiological abnormalities (Barberio, B., et al., 2021). This condition is a prevalent functional bowel disorder, with an estimated prevalence of 14.0%, although this may be an underestimation due to stricter Rome criteria over time (Barberio, B., et al., 2021).

A 2017 study investigated the occurrence of functional constipation among Indians experiencing constipation, as well as their demographic, socio-economic, and clinical characteristics (Rooprai, R., et al., 2017). The findings revealed a significantly higher prevalence of FC (75.6%) with both subtypes exhibiting high PAC-SYM and CSS scores, indicating severe symptoms and poor quality of life (PAC-Qol) (Rooprai, R., et al., 2017). A gender disparity was observed, with a male-to-female ratio of approximately 2:1 among participants. It is noteworthy that a higher number of male participants were involved in this research, which may have affected the male-to-female ratio (Rooprai, R., et al., 2017), potentially influenced by cultural norms and disparities impacting female involvement.

Functional constipation has profound personal, healthcare, and societal ramifications, significantly affecting the QoL for those affected (Mearin, F., et al., 2016). Its severity is influenced not only by bowel symptoms but also by various biopsychosocial factors, including the interplay of gastrointestinal and extraintestinal symptoms, the extent of clinical involvement, and individual perceptions and behaviour (Mearin, F., et al., 2016). The prevalence of FC tends to be higher among women and the elderly, with associated factors including age, increased body mass index (BMI), lower

socio-economic status, and educational level, possibly related to diet and lifestyle habits, reduced mobility, or low self-reported physical activity (Mugie, S. M., et al., 2011). In women suffering from FC, there may be a phenomenon known as abdominopelvic dyssynergia during defecation, charcterised by the inability to properly relax the pelvic floor muscles (PFM), specifically the external anal sphincter (EAS) and the puborectalis muscles of the levator ani (PR-LA), which can obstruct/trigger/hider the contraction or complicate the evacuation process (Vriesman, M. H., et al., 2020; Bo, K., et al., 2017). Patients may also experience rectal hyposensitivity due to either dysfunction in afferent nerve pathways or excessive distension of the rectal wall, necessitating larger stool volumes to trigger defecation, alongside inadequate coordination between rectal and abdominal muscles during stool passage (Andrews, C. N., & Storr, M. 2011; Gladman, M. A., et al., 2006; Diamant, N. E., et al., 1999; Koutsomanis, D., et al., 1995; Dimitriou, N., et al., 2015). Interestingly, two-thirds of women with FC may exhibit paradoxical contractions or involuntary spasms of the anal sphincter during evacuation (Galvão-Alves, J. 2013). However, research into PFM function in this population remains limited. The functionality of PFM encompasses the muscle's ability to contract voluntarily, relax post-contraction, maintain strength, regulate muscle tone and many other factors (Frawley, H., et al., 2021).

Additionally, FC may develop as a learned behaviour from consistently postponing defecation despite experiencing faecal urgency, whether for personal convenience or due to fear of painful bowel movements (Dimitriou, N., et al., 2015). The presence of additional pelvic symptoms can often be linked to poor toileting practices. Research indicates that a significant percentage of women, ranging from 50%-85%, avoid sitting on or hovering over public toilets due to concerns about cleanliness (Moore, K. H., et al., 1991; Cai, D., & You, M. 1998). This alternative position may hinder the relaxation of pelvic-floor and urinary sphincter muscles during micturition (Moore, K. H., et al., 1991). In terms of defecation, evidence suggests that increasing the hip flexion and while sitting relaxed can straightens the anorectal angle, facilitate the opening of the anal canal, and decrease resistance in the anal canal, thereby aiding in stool passage (Tagart R. E. 1966). Consequently, standing or hovering over the toilet may lead to excessive straining during bowel movements and contribute to the onset of Defecatory Disorders (George, S. E., & Borello-France, D. F. 2017). Additionally, specific toileting behaviours, such as neglecting the urge to defecate due to being preoccupied or delaying the act until one is in a private setting, are crucial to identify and address with patients may also contribute to the development of concomitant female pelvic floor disorders (George, S. E., & Borello-France, D. F. 2017). These habits can result in stool retropulsion and exacerbate the individual's condition (George, S. E., & Borello-France, D. F. 2017).

The management of FC demands a clinician with expertise in diagnosis and addressing various motor coordination and musculoskeletal impairments (George, S. E., & Borello-France, D. F. 2017). Intervention strategies for functional constipation require accurate diagnosis, as patients often present with nonspecific symptoms or additional coexisting conditions (George, S. E., & Borello-France, D. F., 2017). An incomplete patient history may lead to mismanagement by healthcare providers. STC and

DD both result in similar stool expulsion challenges and impacts on daily life (George, S. E., & Borello-France, D. F., 2017). However, due to their distinct underlying causes, tailored interventions informed by the International Classification of Functioning, Disability and Health (ICF) framework are crucial to address the unique structural and functional changes associated with each type of constipation (George, S. E., & Borello-France, D. F., 2017).

1.3 Gut Motility & Circadian Rhythm

The suprachiasmatic nucleus, located in the hypothalamus above the optic chiasm, is crucial in regulating circadian rhythms by processing photic signals that influence the biological clock (Salgado-Delgado, R. et al., 2011). The regulation of circadian rhythm is vital for individual health and well-being and is significantly influenced by diverse factors, including lifestyle choices, environmental conditions, and biological mechanisms (Farhud, D., & Aryan, Z., 2018). The interplay between these elements highlights the importance of maintaining consistent sleep-wake patterns and regulating daily schedules to prevent chronic health issues associated with circadian disruptions (Farhud, D., & Aryan, Z., 2018). The research underscores the substantial economic and health benefits of optimising lifestyle factors, such as adjusting school start times, which can enhance academic performance and reduce accident rates (RAND Corporation 2017).

In contrast, individuals in developing countries may adopt irregular routines, which correlates with an increased prevalence of chronic diseases (Farhud, D., & Aryan, Z. 2018). Lifestyle emerges as a significant factor influencing circadian rhythms, acting as a mediator for the effect of other variables (Farhud, D., & Aryan, Z., 2018). Enhancing lifestyle choices and public health policies to promote healthy behavioural changes is paramount (Farhud, D., & Aryan, Z. 2018). While personal choices influence lifestyle, they must be examined within their social and cultural context (Farhud, D., & Aryan, Z. 2018).

Recent evidence establishes that the GI system operates under a circadian rhythm influenced by both central and peripheral factors (Kellow, J. E. et al., 1986; Rao, S. S. et al., 2001; S.S. Rao, et al., 2001; Keller, J., & Layer, P., 2002; Suzuki, A. et al., 2005; Hoogerwerf, W. A., 2009). The molecular framework for these circadian cycles involves intricate transcriptional and translational feedback loops, leading to the rhythmic expression and function of various clock genes and hormones within the GI tract (Duboc, H., Coffin, B., & Siproudhis, L., 2020). Notably, there is a marked increase in bowel activity around waking hours, indicating that the GI system is conditioned for evacuation in the morning (Hoogerwerf, W. A. et al., 2010). Throughout the day, bowel activity remains significantly higher compared to nighttime levels (Narducci, F. et al., 1987; Bampton, P. A. et al., 2001; Rao S. S. et al., 2001; S. S. Rao et al., 2001; Keller J., & Layer P., 2002; Hagger R. et al., 2003; Dinning P. G. et al., 2009). The migrating motor complex (MMC) is a series of electrical waves originating in the stomach that travel through the GI tract, triggering peristaltic conditions (Konturek, P. C., Brzozowski, T., & Konturek, S. J., 2011). Hormones such as motilin and ghrelin play crucial roles in the generation of the

MMC, while others, including gastrin and cholecystokinin facilitate the propagation of these contractions (Konturek, P. C., Brzozowski, T., & Konturek, S. J., 2011). Melatonin secretion is directly regulated by clock genes in the suprachiasmatic nucleus and is significantly synthesised in the GI tract, making it a reliable indicator of circadian rhythm shifts and digestive well-being (Hoogerwerf, W. A. et al., 2006). Melatonin has been shown as effective in treating IBS, and one study conducted on females in which it shows promising results (Lu, W. Z. et al., 2005).

However, several studies investigating circadian rhythms in the GI system have faced challenges in controlling external cues (zeitgebers), such as light-dark cycles and food intake, which can confound results (Khalif, I. L. et al., 2005). Despite this, evidence suggests that constipation is linked to circadian rhythm-dependent variations in colonic transit times following awakening or food consumption, as well as differences in the frequency of bowel movements in comparison to nonconsolidated individuals (Shemerovskii K. A. 2002; Rao, S. S., et al., 2004). Research has pointed to a correlation between disrupted sleep patterns and GI disorders; however, the specific relationship between sleep duration and chronic constipation remains unexamined (Yang S. et al., 2022). These findings highlight the significance of circadian rhythms in GI health and suggest the potential for developing therapeutic approaches that provide improved safety profiles to enhance patient outcomes, including lifestyle changes and exercise regimens (Duboc, H., Coffin, B., & Siproudhis, L., 2020; Yang, S. et al., 2022).

1.4 Gut Motility, Circadian Rhythm, and Exercise

Management of constipation has become a clinical priority over the last decade, driven by the rising global incidence of chronic constipation, particularly in adults. Chronic Functional Constipation, the most common form, is characterised by specific symptom criteria as defined by the Rome guidelines. Due to the high prevalence of this condition, its associated healthcare expenses, and the detrimental effect on QoL, there is an urgent necessity for the formulation of more effective therapies that offer enhanced safety profiles to improve outcomes, such as lifestyle modifications and exercise therapy.

Recent studies have also highlighted the importance of various mind-body interventions on health outcomes related to constipation and overall quality of life across different populations (Yang, S. et al., 2019; Shree Ganesh, H. R. et al., 2021; Staller, K. et al, 2022; Kung, Y. Y. et al., 2024). In 2021, a study on the elderly population evaluated the effect of a three-month yoga intervention as it is a part of mind-body exercises, and they concluded that yoga not only improves constipation but also improves sleep disturbances and QoL, which are common in elderly adults (Shree Ganesh, H. R. et al., 2021). In 2019, the effectiveness of Taiji was investigated concerning its potential to address physical and emotional issues associated with functional constipation (FC) (Yang, S. et al., 2019). This study aimed to clarify the relationship between Taiji practice, brain-gut axis regulation, and emotional disorders in FC patients, indicating that Taiji may offer a unique therapeutic approach in clinical settings compared to traditional aerobic exercise (Yang, S. et al., 2019). Finally, the first report on the Baduanjin exercise indicated improvements in health status, modulation of body constitution, and enhanced circadian rhythm stability among participants (Kung, Y. Y. et al., 2024). Collectively, these findings

support the integration of mind-body interventions as effective complementary treatments for constipation and associated health issues across diverse populations. Further research is warranted to solidify these practices' roles in clinical applications.

Core strengthening exercises (CSE) have the potential to improve GI function; however, there is a lack of extensive research specifically examining their effects, with limited data from randomised controlled trials (Song, B. K. et al., 2021).

Research has shown that graded aerobic exercise can diminish phasic colonic motility in healthy, untrained individuals (Rao, S. S., et al., 1999). However, following exercise, predominantly propagating pressure waves often increase, indicating that physical activity may enhance stool transit (Rao, S. S., et al., 1999). Additionally, acute physical exercise has been shown to elevate high-amplitude propagated contractions (HAPCs) as well as the low-amplitude propagated contractions (LAPCs) in healthy individuals (Cheskin, L. J., et al., 1992). Furthermore, consciously controlled exercise may influence the suprachiasmatic nucleus clock and affect the photic synchronisation of circadian rhythms (Challet E. 2007). For instance, a simulated night-shift exercise study revealed that moderate-intensity exercise during nocturnal shifts resulted in more significant circadian phase shifts than a sedentary control group (Eastman, C. I., et al., 1995). Other studies have also indicated that both low and high intensity exercise conducted during nocturnal shifts can affect circadian rhythm parameters the following day (Van Reeth, O., et al., 1994; Buxton, O. M., et al., 1997). These alterations in circadian rhythms can have substantial implications for GI motility (Duboc, H., Coffin, B., & Siproudhis, L., 2020). In 2017, research demonstrated that increased physical activity significantly improves body mass index and reduces constipation complaints and quality of life among premenopausal women (Tantawy, S. A. et al., 2017). These findings underscore the need for increased awareness and strategies to promote active lifestyles and dietary balance in women experiencing constipation (Tantawy, S. A. et al., 2017).

Therefore, this study aims to evaluate and compare the effectiveness of physio-yogic, pelvic floor exercises and yoga on muscle activation, circadian rhythm and gut health among women with functional constipation.

2. Literature Review

2.1 Gut Health

The term “gut health” is becoming prevalent in both the medical literature and the food industry (Bischoff S. C. 2011). It encompasses various positive aspects of the GI tract, including efficient digestion and nutrient absorption, the absence of gastrointestinal disorders, a stable and balanced gut microbiome, a strong immune response, and overall health (Bischoff S. C. 2011). The GI barrier, which interacts with the GI microbiota, is critical for comprehending the intricate mechanisms that uphold gut health (Bischoff S. C. 2011). Any dysfunction of the gastrointestinal barrier may increase the likelihood of developing infectious, inflammatory, and functional gastrointestinal diseases, as well as extraintestinal conditions like immune-mediated metabolic disorders (Bischoff S. C. 2011).

2.2 Functional Constipation

Constipation is a common GI disease that can be classified as either primary (idiopathic or functional) or secondary due to a range of medical conditions or medications (Bharucha, A. E., & Wald, A., 2019). The Rome criteria classify constipation disorders into 4 subtypes: a) FC, b) IBS, c) OIC, and d) functional defecation disorders (FDD) (Aziz I. et al. 2020). Although the precise mechanism behind chronic FC is not fully elucidated, they are thought to stem from disruptions in gut-brain communication, manifesting as visceral hypersensitivity, abnormal sensory or motor functions, delayed CTT, and altered central perception. In contrast, the mechanism underlying OIC is more clearly defined, primarily involving the activation of opioid receptors, which leads to reduced intestinal secretion and decreased motility (Drossman DA. 2016). FC is defined as a bowel symptom observed without an organic cause.

Functional constipation is characterized by the presence of $\geq$2 of the following criteria over the preceding three months: a) defecatory straining ($\geq$25% BMs); b) hard or lumpy stools ($\geq$25% BMs); c) a sensation of incomplete evacuation ($\geq$25% BMs); d) defecatory obstruction ($\geq$25% BMs); e) manual maneuver of facilitate defecation ($\geq$25% BMs); and f) fewer than 3 spontaneous, complete BMs per week. Symptoms must persist for a minimum of six months before diagnosis, diarrhoea may only occur following laxative use, and criteria for irritable bowel syndrome must not be fulfilled (Longstreth GF et al., 2006).

2.3 Circadian Rhythms and Gut-Brain Interaction

Circadian rhythms are systematic cycles that govern physiological, behavioural, and molecular activities, typically occurring over 24 hours (Fowler, S. et al., 2022). These rhythms are regulated by the suprachiasmatic nucleus (SCN), which acts as the central clock in the brain, orchestrating peripheral circadian clocks and the secretion of melatonin (Fowler, S. et al., 2022). While these circadian systems are internally generated, various external factors, such as light/dark cycles, fasting and feeding patterns, ambient temperature, and physical activity, play a crucial role in aligning the SCN with the surrounding

environment (Fowler, S. et al., 2022). Circadian rhythms facilitate internal temporal organisation, ensuring that physiological changes are cohesively managed (Fowler, S. et al., 2022). Melatonin aids in aligning peripheral clocks with external time cues, and gene expression regulates these rhythms to govern physiological functions (Fowler, S. et al., 2022). The alignment of circadian systems with external environmental cues is crucial for the overall well-being and survival of living organisms (Fowler, S. et al., 2022). Disruptions in circadian rhythms can significantly affect GI function, highlighting their critical role in GI physiology (Fowler, S. et al., 2022). Disorders of gut-brain interactions (DGBIs), also known as functional gastrointestinal disorders (FGIDs), include a variety of conditions characterised by persistent gastrointestinal symptoms not attributable to structural abnormalities, such as functional dyspepsia and irritable bowel syndrome (Fowler, S. et al., 2022). The timing of food intake influences melatonin production, and given the reported connection between dietary consumption and the onset of symptoms in individuals with DGBIs, circadian disruption may be linked to these disorders (Fowler, S. et al., 2022). These disruptions to circadian rhythms can lead to organ disorders or worsen existing ones (Hibberd TJ et al., 2023). Various neural, hormonal, and intraluminal mechanisms may play a role in regulating the circadian variations in colonic functions, although the precise mechanisms of these processes are not fully understood (Hibberd TJ et al., 2023). Unlike melatonin produced by the pineal gland, gut melatonin appears to have a primarily arrhythmic function (Hibberd TJ et al., 2023). However, it may still hold therapeutic potential when used externally for treating gut disorders that are worsened by disruptions in circadian rhythms (Hibberd TJ et al., 2023). Recent advancements in immunology suggest that circadian rhythms are involved in regulating immune responses (Fowler, S. et al., 2022). Patients with DGBIs frequently report symptoms of fatigue and poor sleep quality, further indicating potential circadian disturbances (Fowler, S. et al., 2022). Moreover, studies have shown that melatonin treatment may alleviate symptoms in IBS patients, although the underlying mechanism for this effect remains uncertain (Fowler, S. et al., 2022). Considering the impact of circadian rhythms on both GI function and the immune system, manipulating these rhythms presents a promising strategy for therapeutic intervention aimed at alleviating symptoms in affected patients (Fowler, S. et al., 2022).

2.4 Effect of Exercises on Constipation and Circadian Rhythm

Graded aerobic exercise has been shown to decrease phasic colonic motility in healthy untrained individuals, yet it can enhance stool transit times post-exercise due to a resurgence of propagating pressure waves (Rao, S. S., et al., 1999). Exercise influences the SCN, which regulates circadian rhythms, with moderate-intensity exercise during nocturnal shifts has been found to produce larger circadian phase shifts compared to controls who are sedentary (Challet E. 2007). Both low and high-intensity exercises can affect circadian rhythms the following day (Van Reeth, O., et al., 1994; Buxton, O. M., et al., 1997). Consequently, aerobic exercise is a potential therapeutic intervention for constipation, but current findings do not support clear clinical recommendations (Gao, R. et al., 2019).

Additionally, while yoga is safe and may enhance GI functioning, studies are limited by methodological inconsistencies. Further research is essential to assess yoga's effect on a wider range of GI conditions (Thakur, E. R. et al., 2024).

In 2021, a study on the elderly population evaluated the effect of a three-month yoga intervention as it is a part of mind-body exercises, and they concluded that yoga not only improves constipation but also improves sleep disturbances and QoL, which are common in elderly adults (Shree Ganesh, H. R. et al., 2021). A randomised controlled trial assessed the effect of core stability exercises (CSE) on colonic transit time (CTT) in healthy female university students (Song, B.K. et al., 2021). The CSE group showed significant reductions in left colonic transit time (LCTT) and total colonic transit time (TCTT) but no significant change in overall CTT compared to the control group. In future, more research is required to show the promising effects (Song, B.K. et al., 2021). Other techniques may include stretching, deep and transverse massage, TrP treatment (manual or device-assisted), dry needling, and manual vaginal or anal relaxation. Mobilisation of the hip joints, pelvis, and spine is also beneficial for enhancing mobility and muscle engagement. It may disrupt the hypothalamic–pituitary axis, elevate cortisol levels, and sensitise nociceptive receptors (Tim S., et al., 2021; Khan, A., et al., 2020). Therefore, it is crucial to implement relaxation strategies targeting both the pelvic floor and the surrounding myofascial and nervous system components. Furthermore, consciously controlled exercise may influence the suprachiasmatic nucleus clock and affect the photic synchronisation of circadian rhythms (Challet E. 2007).

3. Research Gaps and Problem Statement

Chronic constipation is a significant health issue in India, affecting approximately 83% of adults aged 18-59, with a higher prevalence in females (20%) compared to males (13%) (Rajput & Saini, 2014). Overall, FC has a high prevalence of 45% worldwide in adults (Palsson OS et al. 2016). Globally, the incidence of functional constipation ranges from 10-16% as per the Rome criteria, and a study in India reported a prevalence of 75.6% for functional constipation, with 36.9% for FC in women (Barberio, B., et al., 2021; Rooprai, R., et al., 2017). It is essential to recognise that the study had a higher number of male participants, which may have impacted the male-to-female ratio within the findings; likely to be influenced by cultural beliefs and disparities affecting female participants (Rooprai, R., et al., 2017). Limitations of the study included its focus on adult populations, lack of long-term data, and a non-interventional methodology (Rooprai, R., et al., 2017). The results are consistent with a recent population-based study conducted in the US that evaluated symptoms, treatment-seeking behaviours, and the impact of the disease on patients with irritable bowel syndrome-constipation and functional constipation, according to Rome III criteria, which reported that 62.7% were diagnosed with FC (Rooprai, R., et al., 2017).

Circadian rhythm disruption is a notable concern among Indian adults, negatively impacting sleep quality and potentially leading to various health issues. While specific prevalence rates for circadian rhythm disorders in India are not widely documented, factors such as shift work, environmental influences, and lifestyle choices are contributing factors. Individuals with certain demographic characteristics and chronic health conditions are particularly vulnerable to poor sleep and circadian misalignment. Circadian rhythms play a vital role in metabolic processes, and the gut microbiome interacts closely with these rhythms, influencing metabolic regulation (Zhao, E., et al., 2022). Disruptions in either the circadian system or gut microbiota can result in metabolic disorders, heightening the risk of chronic conditions like obesity, diabetes, non-alcoholic fatty liver disease (NAFLD), cirrhosis, and hepatocellular carcinoma (Zhao, E., et al., 2022). The gut microbiota contributes to metabolism through mechanisms such as gut barrier integrity, short-chain fatty acid (SCFA) production, inflammatory responses, and bile acid metabolism (Zhao, E., et al., 2022). There is increasing interest in targeted interventions, such as time-restricted feeding, dietary changes, light therapy, prebiotics, probiotics, and faecal microbiota transplantation (FMT), to address gut dysbiosis and circadian misalignment (Zhao, E., et al., 2022). Additionally, an individual's chronotype, defined by time-of-day activity preference, is influenced by genetic and epigenetic factors and impacts overall physical and mental health (Zhao, E., et al., 2022).

Evidence indicates that exercise, particularly pelvic floor exercises, yoga, and physiotherapy, may offer various benefits for individuals with constipation. However, data on their effectiveness, especially for women, remains limited. Thus, there is a pressing need for a rigorous, evidence-based randomised controlled trial to evaluate the effectiveness of these exercise interventions in treating

functional constipation and gut health outcomes concerning circadian rhythms and motor activity, given the absence of comprehensive studies comparing these exercise strategies. Hence, a high-quality, evidence-based study is required to study the different protocols in female patients with functional constipation.

The findings of this study will help to reduce the burden on patients and healthcare workers and reduce the risk of the development of chronic conditions like obesity, diabetes, non-alcoholic fatty liver disease (NAFLD), cirrhosis, and hepatocellular carcinoma by identifying and treating these in the early stage. This will also provide non-pharmacological intervention guidelines for the constipation to the policy maker for improving their overall quality of life.

4. Description of Broad Area

After reading the comprehensive literature related to the present study, we will address the problem that is so common but has been explored less in Indian women.

This study will help to explore the potential benefits of integrative physio-yogic, pelvic floor exercises and yoga protocols in improving symptoms related to functional constipation and associated risk factors. This study will develop and validate protocols of integrative physio-yogic, pelvic floor exercises and yoga to improve muscle activation, circadian rhythm and gut-health outcomes among women with functional constipation. This field of study will also help us to compare and determine the effectiveness of non-pharmacological interventions such as physio-yogic exercises, pelvic floor exercises, and yoga in managing functional constipation among women.

This study will also explain the physiological and biopsychosocial model, such as circadian rhythm, psychological factors, physical activity, etc. and their influence on functional constipation and how these interventions improve these factors.

5. Research Objectives

Aim: To evaluate and compare the effectiveness of physio-yogic exercises, pelvic floor exercises and yoga on muscle activation, circadian rhythm and gut health among women with functional constipation.

Objectives:

- To study the effectiveness of physio-yogic exercises on muscle activation, circadian rhythm and gut health among women with functional constipation.
- To study the effectiveness of pelvic floor exercises on muscle activation, circadian rhythm and gut health among women with functional constipation.
- To study the effectiveness of yoga on muscle activation, circadian rhythm and gut health among women with functional constipation.
- To compare the effectiveness of the physio-yogic exercises, pelvic floor exercises and yoga on muscle activation, circadian rhythm and gut health among women with functional constipation.

Research Questions:

- Will physio-yogic, pelvic floor exercises and yoga be significantly effective on muscle activation, circadian rhythm and gut health outcomes in women with functional constipation?

Alternate Hypothesis (H_a):

- H_{a1}: There will be significant differences in the effectiveness of physio-yogic exercises, pelvic floor exercises and yoga protocols on muscle activation, circadian rhythm and gut health among women with Functional constipation.

Sub-Hypothesis:

- $H_{a1(i)}$: There will be significant differences in the effectiveness of physio-yogic exercises on muscle activation, circadian rhythm and gut health among women with Functional constipation.
- $H_{a1(ii)}$: There will be significant differences in the effectiveness of pelvic floor exercises on muscle activation, circadian rhythm and gut health among women with Functional constipation.
- $H_{a1(iii)}$: There will be significant differences in the effectiveness of yoga on muscle activation, circadian rhythm and gut health among women with Functional constipation.

Null Hypothesis (H_0):

- H_{01}: There will be no significant differences in the effectiveness of physio-yogic exercises, pelvic floor exercises and yoga protocols on muscle activation, circadian rhythm and gut health among women with Functional constipation.

6. Research Methodology

6.1 Study Design:

Experimental Study: Randomized Control Trial

6.2 Sample Size:

N = 92 Calculated by G*Power 3.1.9.4 software with the effect size of 0.2, power 0.95 and significance level of 0.05 a priori.

Test: ANOVA: Repeated measures, within-between interaction

Analysis: A priori: Compute the required size

The total sample size will be N = 100. The potential loss to attrition was estimated at 5-10%.

6.3 Sampling Technique: Convenient Sampling with Random Allocation

6.4 Inclusion Criteria:

i. Female 18-40 years of age

ii. Meeting the Criteria of ROME-III for Functional Constipation, along with the Bristol Scale (Rooprai, R., et al.2017)

iii. The symptoms persist for at least 3 months (<3 bowel movements per week)

iv. BMI: 18.5-24.9 Kg/m^2 (Misra A. et al., 2025)

v. Provide a written informed consent form and agree to fill PAR-Q.

vi. Fulfil the criteria of the Readiness of exercises questionnaire (Physical Activity Readiness Questionnaire – PAR-Q)

6.5 Exclusion Criteria:

i. Pregnant or Lactating Female (History of pregnancy or lactation in the last 1 year or with complications)

ii. History of any abdominal or other surgeries, such as hysterectomy, ostomy

iii. Have any history of trauma, cardiovascular, metabolic, psychiatric, musculoskeletal, neurological, cancer, renal or respiratory disorders, history of any musculoskeletal injury (in the last 2 years), and systemic illness

iv. Diagnosed cases of anal stenosis or atresis, hemorrhoids, anal fissure, anal fistula, anteriorly displaced anus, imperforate anus, obstructing tumors, malignancies, and anal stricture.

v. Already participated in physical exercise treatment and is receiving any medication or

treatment that has superimposing effects (e.g. Hormonal therapy)

vi. History of taking any medicines such as opioids, steroids, in the last 7 days.

vii. History of PFD, PCOS, PCOD, prolapse: Ovarian, Uterine or Rectal, Bladder & Bowel incontinence, urinary tract infection

viii. Facing pain and discomfort during testing or the study protocol

ix. Obese women associated with any Digestive, gastrointestinal and abdominal surgical complications will be excluded

x. Participants with cognitive impairments are unable to understand the procedure of the study and the informed consent form, or participants having any disagreements in filling informed consent form

6.6 Groups: 100 participants will be equally allocated in 4 groups:

Group A: Physio-Yogic Exercises (N=25)

Group B: Pelvic Floor Exercises (N=25)

Group C: Yoga (N=25)

Group D: Control (N=25)

6.7 Variables:

Dependent variables: Outcome Measures –

a. Electromyography (EMG)

b. Morningness and Eveningness Questionnaire (MEQ)

c. PAC-QoL (Patient Assessment Constipation Quality of Life)

d. Constipation Severity Score (CSS)

e. Rome III, along with the Bristol Scale

f. Frequency of Bowel movements per week

g. Kuppuswamy socioeconomic scale

h. Kessler Psychological Distress Scale (K10)

i. Dietary Intake and Food Quality (Food Frequency Quality using serial 24-h recalls (FFQ))

j. IPAQ

Independent variables: Interventions –

a. Physio-Yogic Exercises

b. Pelvic Floor Exercises

c. Yoga

d. Control

6.8 Outcome Measures:

Muscle Activation

a) Electromyography (surface EMG)

Circadian Rhythm

b) Morningness and Eveningness Questionnaire (MEQ)

Gut Health

c) Patient Assessment Constipation Quality of Life (PAC-QoL)

d) Constipation Severity Score (CSS)

e) Rome III, along with the Bristol Scale

f) Frequency of Bowel movements per week

Other Outcome Measures

g) Kuppuswamy socioeconomic scale (Modified)

h) Kessler Psychological Distress Scale (K10)

i) Food Frequency Quality using serial 24-h recalls (FFQ)

j) IPAQ (SF)

6.9 Exercise Protocol:

A) Physio-Yogic Exercise:

B) Pelvic Floor Exercise:

C) Yoga:

D) Control:

Table 1: Exercise Protocols

Group A: PHYSIO-YOGIC EXERCISES PROTOCOL	**Group B: PELVIC FLOOR EXERCISES PROTOCOL** (Harrington and Haskvitz 2006)	**Group C: YOGA PROTOCOL** (Satyananda, S. S. et al., 1969)	**Group D: CONTROL**
BEGINNER **20 minutes (25 – 30 minutes with rest breaks) - (week 1-4) – 15 sessions total in 4 weeks; Weekly 4 sessions** **(2-3 seconds rest in 1 repetition & 60-90 seconds rest in each set)** **Education Program**	**BEGINNER** **20 minutes (25 – 30 minutes with rest breaks) - (week 1-4) – 15 sessions total in 4 weeks; Weekly 4 sessions** **(Hold 05 seconds; 2-3 seconds rest in 1 repetition & 60-90 seconds rest in each set)** **Education Program**	**BEGINNER** **20 minutes (25 – 30 minutes with rest breaks) - (week 1-4) – 15 sessions total in 4 weeks; Weekly 4 sessions** **(2-3 seconds rest in 1 repetition & 60-90 seconds rest in each set)** **Education Program**	**Education Program**
• Mantra Chant – (2 min) • Vajarasna – 2 minutes • Tadasana – 2 Round – 1 min. • Side Bend Tadasana – 2 Round – 1 min. • Pawanmukt Asana – 2 Round – 2 min • Nauka Sanchalan Aasna – 5 Round – 3 min + • Kegel exercises Two series of 10 repetitions with 5 seconds hold – (In supine) • Pelvic tilts (In supine & sitting position) Two series of 10 repetitions • Abdominal bridges (Two series	• Standard diaphragmatic breathing was achieved using sitting posture, with one hand resting on the abdomen and the other on the thoracic region. the subject was instructed to inhale slowly and deeply over a duration of 2-3 seconds, followed by 5 seconds breath hold, and then exhale gradually for 2-3 seconds. This sequence was performed for 2 sets of 10 repetitions. The exercise was deemed successful when an enhanced movement of the hand on the abdomen was observed in contrast to minimal or no movement of the hand on thorax, which marked the initiation point for the series. • When sitting on a chair lean forward and position the feet on a	• Mantra Chant – (2 min) • Sidhasana – 1 Round – 1 min. • Tadasana – 2 Round – 1 min. • Side Bend Tadasana – 2 Round – 1 min. • Katichakrasana – 2 Round □ 1 min. • Meru Vakrasana – 10 Round – 2 min. • Paschimotanasana – 2 Round – 1 min. • Cleansing Practice: • Agni Sar Kriya – 2 Round – 2 min. • Vat Karma Kapalbhati– 2 Round – 30 strokes in 1 round – 2 min. • Nadi shuddhi prayanama – 2	• Normal ADL's.

of 10 times) with 5 seconds hold	step stool (hold 5 s for Two series of 5 times) • Kegel exercises Two series of 10 repetitions with 5 seconds hold – (In supine) • Reverse Kegel exercises Two series of 10 repetitions with 5 seconds hold – (In supine) • Pelvic tilts (In supine & sitting position) Two series of 10 repetitions • Abdominal bridges (Two series of 10 times) with 5 seconds hold • Squatting Two series of 10 repetitions with 5 seconds hold	Round – 3 min. • Surya Bhedi prayanama – 2 Round – 2 min. • Shanti Path Chant – 2 min	
ADVANCED **44 minutes (45 – 50 minutes with rest breaks) - (week 4-8) – 15 sessions total in 4 weeks; Weekly 4 sessions** **(2-3 seconds rest in 1 repetition & 60-90 seconds rest in each set)** **Continued Education Program**	**ADVANCED** **44 minutes (45 – 50 minutes with rest breaks) - (week 4-8) – 15 sessions total in 4 weeks; Weekly 4 sessions** **(Hold 10 seconds; 2-3 seconds rest in 1 repetition & 60-90 seconds rest in each set)** **Continued Education Program**	**ADVANCED** **44 minutes (45 – 50 minutes with rest breaks) - (week 4-8) – 15 sessions total in 4 weeks; Weekly 4 sessions** **(2-3 seconds rest in 1 repetition & 60-90 seconds rest in each set)** **Continued Education Program**	**Continued Education Program**
• Mantra Chant – (2 min) • Vajarasna – 2 minutes • Tadasana – 2 Round – 1 min. • Side Bend Tadasana – 2 Round – 1 min. • Pawanmukt Asana – 2 Round – 2 min • Kast Takshan Asana – 5 Round –	• Standard diaphragmatic breathing was achieved using sitting posture, with one hand resting on the abdomen and the other on the thoracic region. the subject was instructed to inhale slowly and deeply over a duration of 6-8 seconds, followed by 10 seconds	• Mantra Chant – (2 min) • Vajarasna – 2 minutes • Pawanmukt Asana – 2 Round – 2 min • Rajju Karshan Asana – 5 Round – 3 min	• Normal ADL's.

3 min. • Nadi shuddhi prayanama – 2 Round – 3 min. + • Kegel exercises Three series of 20 repetitions with 3 seconds hold – (In supine) • Pelvic tilts (In supine & sitting position) three series of 20 repetitions • Abdominal bridges (Three series of 20 times) with 10 seconds hold • Crunches Three series of 20 repetitions with 10 seconds hold • Squatting Three series of 20 repetitions with 10 seconds hold	breath hold, and then exhale gradually for 6-8 seconds. This sequence was performed for 3 sets of 15 repetitions. The exercise was deemed successful when an enhanced movement of the hand on the abdomen was observed in contrast to minimal or no movement of the hand on thorax, which marked the initiation point for the series. • When sitting on a chair lean forward and position the feet on a step stool with 10 s hold for Three series of 5 times • Kegel exercises Three series of 20 repetitions with 10 seconds hold – (In supine) • Reverse Kegel exercises Three series of 20 repetitions with 10 seconds hold – (In supine) • Pelvic tilts (In supine & sitting position) Three series of 20 repetitions • Abdominal bridges (Three series of 20 reps) with 10 seconds hold • Plank Holds Three series of 20 repetitions with 10 seconds hold • Squatting Three series of 20 repetitions with 10 seconds hold	• Meru Vakrasana – 15 Round – 4 min • Chakki Chalanasana – 5 Round – 3 min • Nauka Sanchalan Aasna – 5 Round – 3 min • Kast Takshan Asana – 5 Round – 3 min • Hastotanasana & Padastaasana – 10 Round – 2 min • Cleansing Practice: Agni Sar Kriya - 5 Round – 4 min Vat Karma Kapalbhati - 4 Round; 30 strokes in 1 round – 4 min • Nadi shuddhi prayanama - 5 Round – 5 min • Ujjayi prayanama - 5 Round – 4 min • Shanti Path CHANT – 2 min	

Operational Definitions:

- **Gut Health:** Gut health is defined as the absence of GI symptoms (e.g., abdominal pain and diarrhoea) and diseases such as inflammatory bowel disease and colon cancer.
- **Circadian Rhythm:** Circadian rhythm is the natural cycle of an organism's physical, mental, and behavioural changes over a 24-hour cycle.
- **Muscle Activation:** Muscle activity refers to the electrical signals generated during rest that change with movement, commonly recorded using surface electromyogram (sEMG).

Procedure:

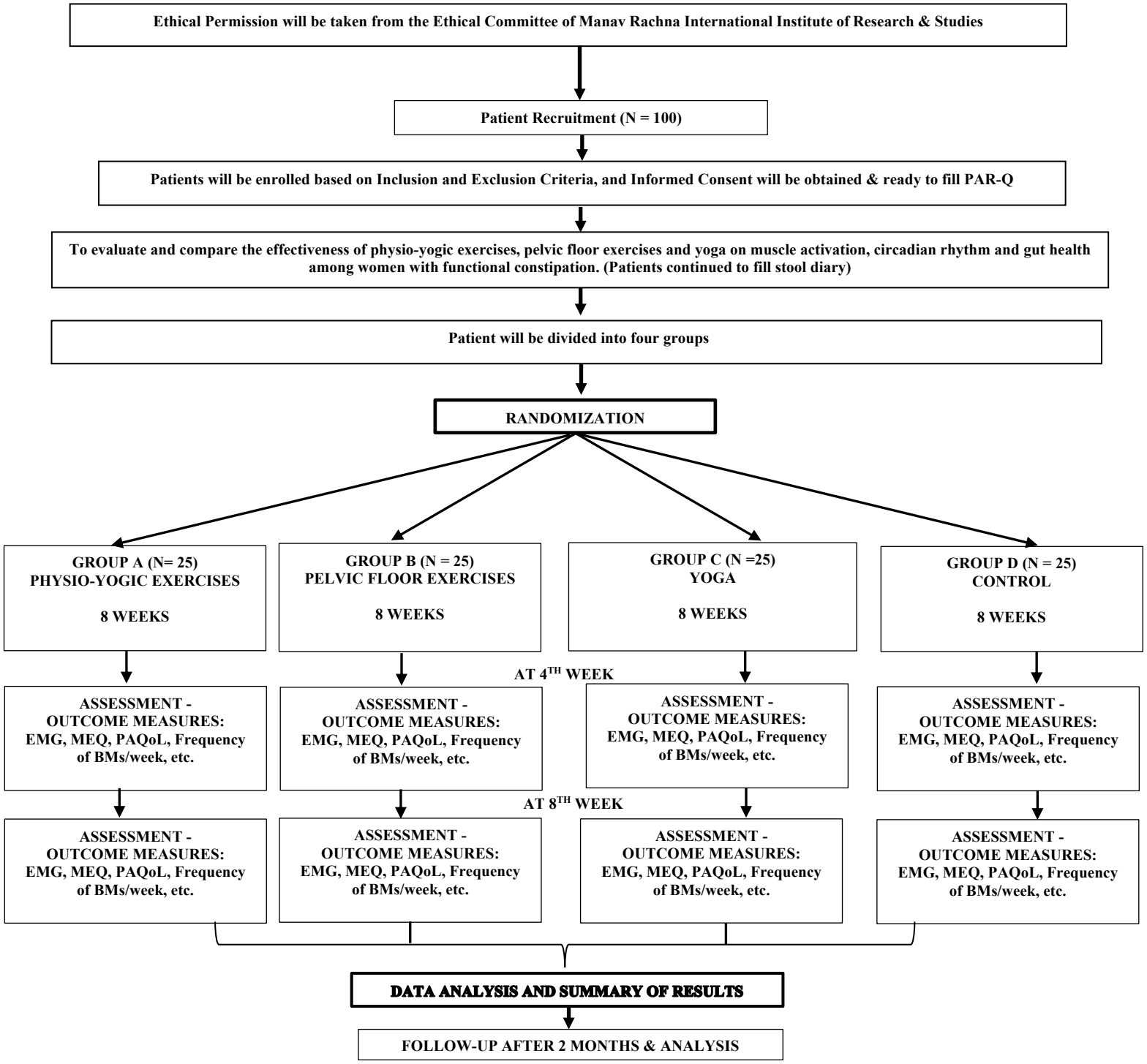
Ethical Permission will be taken from the Ethical Committee of Manav Rachna International Institute of Research & Studies
Patient Recruitment (N = 100)
Patients will be enrolled based on Inclusion and Exclusion Criteria, and Informed Consent will be obtained & ready to fill PAR-Q
To evaluate and compare the effectiveness of physio-yogic exercises, pelvic floor exercises and yoga on muscle activation, circadian rhythm and gut health among women with functional constipation. (Patients continued to fill stool diary)
Patient will be divided into four groups
RANDOMIZATION
GROUP A (N= 25) PHYSIO-YOGIC EXERCISES 8 WEEKS
GROUP B (N = 25) PELVIC FLOOR EXERCISES 8 WEEKS
GROUP C (N =25) YOGA 8 WEEKS
GROUP D (N = 25) CONTROL 8 WEEKS
AT 4TH WEEK
ASSESSMENT - OUTCOME MEASURES: EMG, MEQ, PAQoL, Frequency of BMs/week, etc.
ASSESSMENT - OUTCOME MEASURES: EMG, MEQ, PAQoL, Frequency of BMs/week, etc.
ASSESSMENT - OUTCOME MEASURES: EMG, MEQ, PAQoL, Frequency of BMs/week, etc.
ASSESSMENT - OUTCOME MEASURES: EMG, MEQ, PAQoL, Frequency of BMs/week, etc.
AT 8TH WEEK
ASSESSMENT - OUTCOME MEASURES: EMG, MEQ, PAQoL, Frequency of BMs/week, etc.
ASSESSMENT - OUTCOME MEASURES: EMG, MEQ, PAQoL, Frequency of BMs/week, etc.
ASSESSMENT - OUTCOME MEASURES: EMG, MEQ, PAQoL, Frequency of BMs/week, etc.
ASSESSMENT - OUTCOME MEASURES: EMG, MEQ, PAQoL, Frequency of BMs/week, etc.
DATA ANALYSIS AND SUMMARY OF RESULTS
FOLLOW-UP AFTER 2 MONTHS & ANALYSIS

Figure 1: Study Procedure

7. Expected Outcome of the Research

This study will help to develop and validate new non-pharmacological rehabilitation protocols to improve the functional constipation, gut motility, and overall quality of life of the individuals affected by this condition. By designing the protocol, we can help our community to get rid of this problem and improve their health outcomes. Reiterating the positive outcomes of exercise protocols can strengthen the justifications for incorporating exercise programs as a fundamental component of health and wellness initiatives in modifying motor activity, gut health, circadian rhythm and facilitating healthy lifestyles, especially in women. This study will also help in reducing the economic burden on patients and healthcare professionals.

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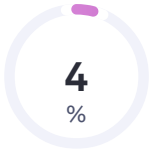

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